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Intermountain Power Project

OverScrub™ Technology
Contract 01-45527

Preliminary Test Report

Test Module Performance Testing

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Reviewed By: Keith Benton

Date: October 2, 2001

STAFF.
FOR YOUR REVIEW. I STILL HAVE SEVERAL CONCERNS ABOUT THE RESULTS THAT WE WILL DISCUSS LATER AFTER I GET SOME ANSWERS FROM RADIAN.

JERRY

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Introduction:

URS and IPSC entered into a contract (No. 01-45527) on July 30, 2001 to install URS's OverScrub™ technology in the Intermountain Power Project FGD system in an effort to a.) reduce SO_2 emissions, and b.) decrease the overall power requirement of the FGD system by improving the SO_2 removal performance of the towers such that the current SO_2 emissions from the plant can be maintained while operating the absorbers with one fewer recycle pump.

With these two objectives, URS supplied drawings for manufacture of absorber liquid redistribution devices and modification of a single absorber tower for commercial demonstration of the performance of the improvements. The body of this report presents the data and results from testing of the modified tower in direct comparison with testing of an unmodified tower.

Included in this report is a discussion of the testing experience, presentation of the data, presentation of test results, conclusions and relevance to performance guarantees, and recommendations for additional performance improvements. In addition, for completeness, the test report from the third party test crew and the analysis of the scrubber chemistry are included.

Executive Summary:

The URS and IPSC contract (No. 01-45527) to install and operate the URS's OverScrub™ technology in the Intermountain Power Project FGD system required that absorber performance be demonstrated on a single test module prior to complete implementation on all twelve modules. The performance requirements as quoted from the referenced contract are;

1. SO_2 emissions from each scrubber module, with all recycle pumps operating and the spray nozzles in good repair, will be reduced by at least 50 percent with the installation of the this technology.

2. After installation of the this technology, each scrubber module may be operated with only two (2) and any two (2) recycle pumps in service such that the SO_2 emissions from the modified scrubber with any two (2) spray levels in service is less than or equal to the SO_2 emissions from any unmodified scrubber with three (3) spray levels in service as demonstrated by performance testing of the demonstration module.

In order to verify the test module met the two criteria above, URS in conjunction with IPP and American Environmental Testing Co. (AET) tested the modules by sampling the flue gas flow, temperature, and SO_2 content at 30 points equally distributed above the mist eliminator. AET used a long sample probe to span the entire tower. After initial test problems associated with sampling a saturated flue gas stream and dropping out water, AET was able to effectively measure the required data using a dilution method (similar to the method used in the IPP stack) to accurately determine the SO_2 content above the mist eliminator.

The details surrounding the result of this testing can be found in the results section. Relative to the contractual requirements the following table summarizes the results.

Table 1: Test 1 Module B&C Comparison – 3 Pump Operation

Module	Average Velocity, Ft/sec	Average SO_2 Concentration, ppm	Average SO_2 Emissions, lbs/H
1-B (Modified)	**10.2**	**14.6**	**52.1**
1-C (Unmodified)	**10.3**	**48.4**	**169.9**

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Table 2: Test 2 Module B&C Comparison – 2 Pump Operation on Module B

Module	Average Velocity, Ft/sec	Average SO_2 Concentration, ppm	Average SO_2 Emissions, lbs/H
1-B (Modified)	**11.4**	**34.6**	**140.2**
1-C (Unmodified)	**9.1**	**48.3**	**157.4**

Table 3: Test 3 Module B&E Comparison – 3 Pump Operation

Module	Average Velocity, Ft/sec	Average SO_2 Concentration, ppm	Average SO_2 Emissions, lbs/H
1-B (Modified)	**10.3**	**16.1**	**59.4**
1-E (Unmodified)	**10.1**	**42.2**	**157.1**

From the data presented here it is possible to determine the effectiveness of the module modifications relative to the requirements of the contract.

Guarantee 1: Greater than 50% Reduction SO_2 Mass Emissions with Both Towers Operating with 3 pumps in Operation

The performance of the modified module B far exceeds this requirement. As seen in Tests 1 and 3, with three pumps in operation, the modified module has an SO_2 emission of 37.8% of module E and 30.6% of module C. Both of these values are well below the guarantee value of 50% reduction, even though the velocity to the modified module was approximately the same in both cases.

Guarantee 2: Similar SO_2 emissions from the Modified Tower with Two Pumps In Operation as the Towers with Three Pumps in Operation

The performance of the modified module B also exceeds this requirement. As seen in Tests 2, with two pumps in operation, the modified module has an SO_2 emission rate of 140.2 lbs/h versus an emission rate from module C of 157.4 lbs/H. This represents a reduction in emissions rates of 11% even though the module was processing 25% more flue gas. When the recycle pump was removed from service, the pressure drop in the modified tower dropped and thus the module was forced to process more flue gas as a result. Even under this testing abnormality, the modified tower met and exceeded the required performance.

Additional performance enhancements can be achieved at this site by modifying all 12 of the absorber modules. Placement of the rings in the module could further enhance performance of SO_2 removal and also mist eliminator depending on IPP long term operation goals.

URS concludes from all of the data collected and presented that the modified tower has met and exceeded all performance requirements of the contract.

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Testing:

The requirements of testing the units above the mist eliminator and spanning a 35 foot duct made for some challenging tests. AET built a 30 foot sample probe that would allow the unit to be tested in 30 different locations as shown in Figure 1.

IPP Scrubber Module Traverse Points

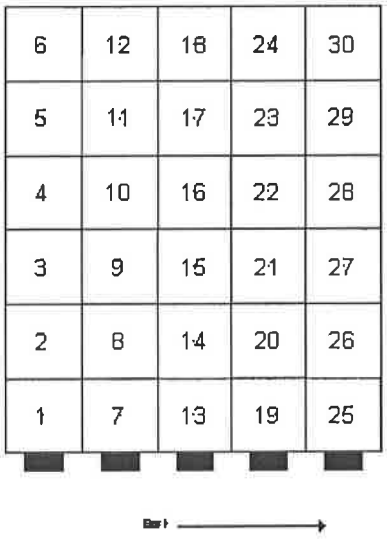

Figure 1: Test Sample Locations – Note Gas Inlet and Outlet on Left for Modules B&C and Right For Module E

The first couple of days of testing were spent troubleshooting the test system and test method. It was initially believed that the flue gas sample from the absorber outlet could be taken, chilled to drop out water and then the SO_2 concentration measured directly by an analyzer. An initial test on the B and E towers provided erroneous results with each tower showing approximately 1.5 ppm outlet SO_2 on average. It was suspected that the water drop out caused the removal of SO_2 from the sample as well. A heated probe was attempted but the a glass wool trap was necessary to protect the analyzer internals. This too proved to be ineffective in producing any meaningful results.

After discussions with the analyzer manufacturers it was decided that this service and type of testing could only be accommodated by using a dilution method. Successful testing was conducted on Thursday, September 20, 2001 using this dilution method. The results are shown in the next section. The process parameters tested are as follows.

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Table 4: Test 1 Module B&C Comparison – 3 Pump Operation

Module	pH	Pumps In Service
1-B (Modified)	**5.7**	**HP, IP, LP**
1-C (Unmodified)	**5.7**	**HP, IP, LP**

Table 5: Test 2 Module B&C Comparison – 2 Pump Operation (B)

Module	pH	Pumps In Service
1-B (Modified)	**5.7**	**HP, LP**
1-C (Unmodified)	**5.7**	**HP, IP, LP**

Table 6: Test 3 Module B&E Comparison – 3 Pump Operation

Module	pH	Pumps In Service
1-B (Modified)	**5.7**	**HP, IP, LP**
1-E (Unmodified)	**5.7**	**HP, IP, LP**

Because the nature of the heated dilution prove and analyzer method was much more complicated than anticipated, it was not possible to analyze both towers simultaneously. But random checks of boiler conditions indicated relatively stable conditions throughout September 20, 2001. Furthermore, because the probes and lines needed to be heated, the sample analyzer was required to be on the process platform and not in the test trailer. For each sample point (180 total) the analyzer had to be moved each time a new point was tested. For this reason, B and C modules were chosen to compare for the first two tests to make the switch from each module the easiest. When the last test on the B tower was completed the entire testing apparatus was moved from the A-B-C side to the D-E-F side and module E was tested. This verified that there were no significant differences in either gas flow or module performance between modules C or E.

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Test Data & Results:

The test results are most easily summarized in tabular and graphical form. The following section presents the actual measured test results for each test and two plots of SO_2 emissions versus position in the tower. Further results including chemistry analysis will be included in the final report.

Test 1 – B & C Module Comparison, Three Pump Operation

Figures 2a: Module 1B Test 1

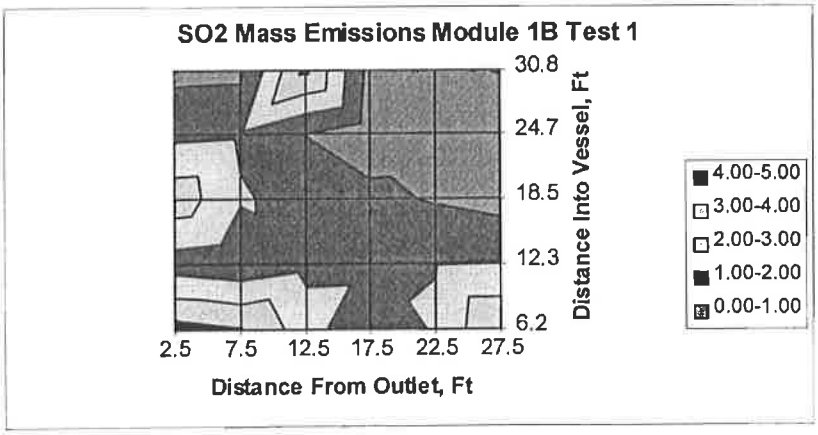

Figure 3: Module 1C Test 1

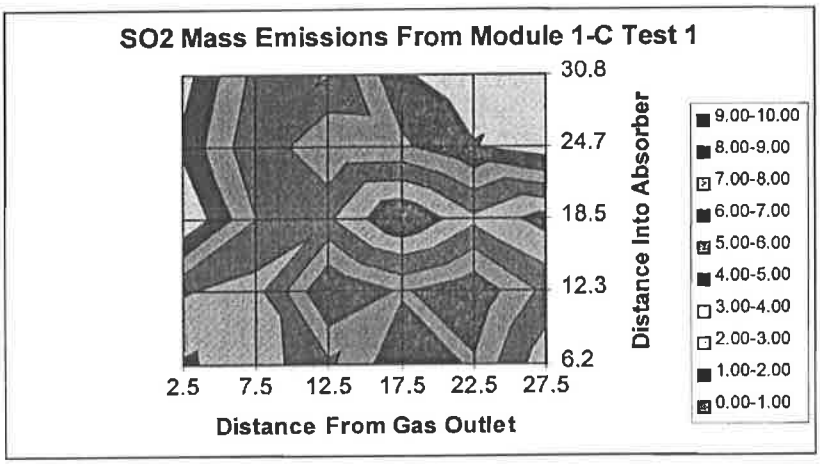

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Table 7: Test Data Results For Module 1B Test 1

Intermountain Power Project

Scrubber Unit 'B'
(West to East)

Date: 9/20/2001
Start : 905 Stop : 1125

A_s	900.00	ft^2
C_p	0.900	
P_g	1.900	*in. H2O*
P_{bar}	25.500	*in. Hg*
P_s	25.640	*in. Hg*
Ms	28.570	*lb/lb-mole*
Bws	0.134	

	ΔP (in. H2O)	Sqrt ΔP (in. H2O)	Ts °F	Vs ft/sec	Qs std dscf/hr	SO2 ppm	SO2 lbs/hr	
1	0.032	0.1789	121	12.2577	887947.5	29.7	4.377759	
2	0.057	0.2387	119	16.3314	1187131	20.5	4.039805	
3	0.047	0.2168	121	14.8554	1076121	13.9	2.483042	
4	0.054	0.2324	121	15.9232	1153478	4.9	0.938239	
5	0.075	0.2739	121	18.7657	1359386	9.6	2.166318	
6	0.072	0.2683	121	18.3866	1331921	18	3.979781	16.1
7	0.007	0.0837	120	5.7281	415657.3	22	1.51798	
8	0.011	0.1049	121	7.1867	520605.3	14.7	1.270381	
9	0.018	0.1342	121	9.1933	665960.6	15.5	1.713517	
10	0.02	0.1414	120	9.6822	702589	15.1	1.76111	
11	0.021	0.1449	121	9.9299	719319.7	16.3	1.946335	
12	0.018	0.1342	119	9.1774	667109.8	17.8	1.971176	
13	0.051	0.2258	121	15.4746	1120979	19.4	3.61	
14	0.024	0.1549	119	10.5972	770312	16.3	2.08431	
15	0.023	0.1517	118	10.3651	754745.2	13.9	1.741499	
16	0.011	0.1049	119	7.1743	521503.7	14.5	1.255259	
17	0.005	0.0707	119	4.8369	351597.7	15.4	0.898824	
18	0.002	0.0447	119	3.0591	222369.9	17.1	0.631219	
19	0.017	0.1304	118	8.9112	648874.8	16.7	1.798811	
20	0.019	0.1378	120	9.4371	684799.1	16.4	1.864297	
21	0.005	0.0707	120	4.8411	351294.5	17	0.991353	
22	0.001	0.0316	120	2.1650	157103.7	16.6	0.432915	
23	0.001	0.0316	119	2.1631	157239.3	17.9	0.467221	
24	0	0.0000	119	0.0000	0	5.9	0	
25	0.018	0.1342	121	9.1933	665960.6	6.5	0.718571	
26	0.024	0.1549	119	10.5972	770312	6	0.767231	
27	0.037	0.1924	120	13.1693	955624.4	26.6	4.219655	
28	0.061	0.2470	126	16.9965	1220721	3.3	0.668711	
29	0.046	0.2145	123	14.7217	1062784	4.4	0.776257	
30	0.051	0.2258	122	15.4879	1120015	5.6	1.041166	8.73
average =	0.03	0.1492	120.27	10.2203	22223462	14.58333	52.13274	

13.77 AVERAGE OUTSIDE
15.2 INSIDE

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Table 8: Test Data Results For Module 1C Test 1

Intermountain Power Project

Scrubber Unit 'C'
(West to East)

Date: 9/20/2001
Start : 1300 Stop : 1430

A_s	900.00	ft^2	
C_p	0.900		
P_g	1.900	*in. H2O*	
P_{bar}	25.500	*in. Hg*	
P_s	25.640	*in. Hg*	
Ms	28.570	*lb/lb-mole*	
Bws	0.134		

	ΔP (in. H2O)	Sqrt ΔP (in. H2O)	Ts °F	Vs ft/sec	Qs std dscf/hr	SO2 ppm	SO2 lbs/hr	
1	0.014	0.1183	122	8.1147	586817.3	83.5	8.133874	
2	0.01	0.1000	125	6.8758	494677.8	91.6	7.521873	
3	0.013	0.1140	125	7.8396	564019.5	65.9	6.170035	
4	0.018	0.1342	124	9.2170	664247.9	38.5	4.245208	
5	0.025	0.1581	124	10.8623	782823.6	39.5	5.132975	
6	0.028	0.1673	123	11.4858	829172.9	56.1	7.721755	62.52
7	0.014	0.1183	122	8.1147	586817.3	71.1	6.925969	
8	0.015	0.1225	124	8.4139	606372.6	73.8	7.428549	
9	0.007	0.0837	125	5.7527	413877.1	56.9	3.909235	
10	0.012	0.1095	128	7.5514	540508.2	57.1	5.123261	
11	0.018	0.1342	128	9.2485	661984.7	38.7	4.252722	
12	0.02	0.1414	127	9.7405	698387.2	54.1	6.271936	
13	0.007	0.0837	124	5.7478	414231.3	43.3	2.977412	
14	0.016	0.1265	125	8.6973	625723.4	57.4	5.962143	
15	0.022	0.1483	127	10.2159	732474.7	56.3	6.845562	
16	0.041	0.2025	129	13.9700	998239.2	54.5	9.03107	
17	0.049	0.2214	128	15.2592	1092219	40	7.252334	
18	0.04	0.2000	126	13.7634	988511.1	51.1	8.385144	
19	0.015	0.1225	127	8.4355	604821.1	42	4.216813	
20	0.033	0.1817	127	12.5119	897094.7	45.6	6.790648	
21	0.019	0.1378	127	9.4938	680703.7	44.6	5.039658	
22	0.018	0.1342	128	9.2485	661984.7	47.4	5.20876	
23	0.024	0.1549	129	10.6883	763744.9	32	4.057013	
24	0.019	0.1378	130	9.5181	678970.9	28.8	3.246024	
25	0.014	0.1183	126	8.1425	584811	36.8	3.572494	
26	0.037	0.1924	127	13.2485	949909.3	40	6.307398	
27	0.042	0.2049	128	14.1273	1011198	42	7.050075	
28	0.043	0.2074	123	14.2336	1027544	24.2	4.127849	
29	0.044	0.2098	121	14.3734	1041211	19.4	3.353115	30.18
30	0.049	0.2214	121	15.1681	1098779	20.1	3.666186	
average =	0.02	0.1502	125.67	10.3353	22281877	48.41	169.9271	

~~50.35~~ OUTSIDE

47.14
50.35

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Test 2: Two Pump Operation on Module B Compared to Module C

The most significant test parameter to change in this test condition is elimination of the Intermediate Pressure pump from operation on the B module. The C and E module remained unchanged. As is evident in Tables 9 and 10 this caused a significant mal distribution of gas flow to the B module. The reduction of pressure drop because a recycle pump was turned off caused more gas to flow through the B module than the other three. This further reduced the "effective" L/G by increasing the G to the B vessel by over 10%. Thus, the actually L/G reduction in this case was nearly 40% not 33% as originally assumed.

Figure 3a: Module 1B Test 2 (Two Pump Operation)

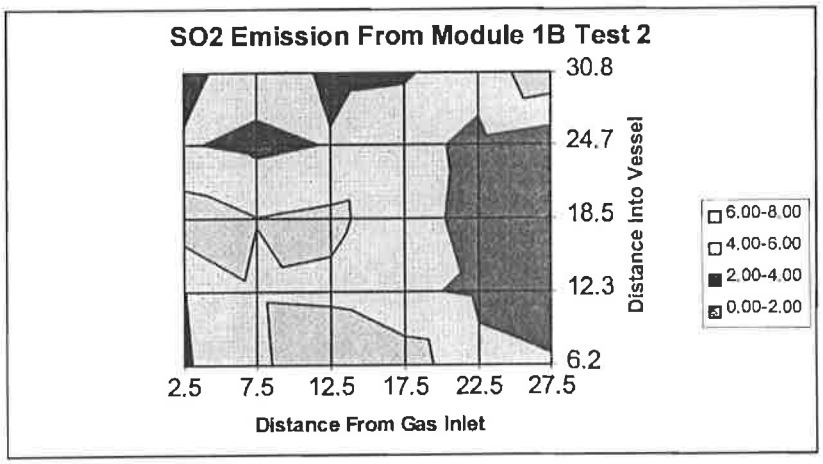

Figure 3b: Module 1C Test 2

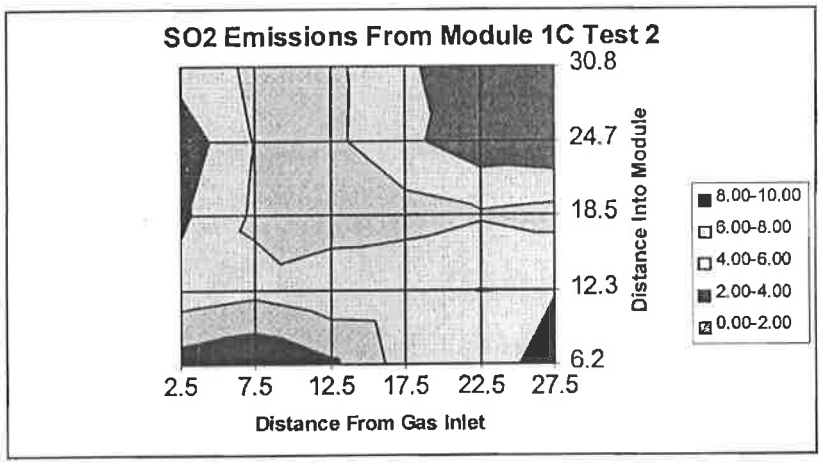

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Table 9: Test Data Results For Module 1B Test 2 (Two Pump Operation)

Intermountain Power Project

Scrubber Unit 'B'
(West to East)

Date: 9/20/2001
Start : 1700 Stop : 1920

A_s	900.00	ft^2						
C_p	0.900							
P_g	1.900	*in. H2O*						
P_{bar}	25.500	*in. Hg*						
P_s	25.640	*in. Hg*						
Ms	28.570	*lb/lb-mole*						
Bws	0.134							

	ΔP (in. H2O)	Sqrt ΔP (in. H2O)	Ts °F	Vs ft/sec	Qs std dscf/hr	SO2 ppm	SO2 lbs/hr
1	0.023	0.1517	115	10.3382	756711.5	29.9	3.755862
2	0.026	0.1612	113	10.9726	805953	42.1	5.632483
3	0.056	0.2366	115	16.1315	1180757	38.1	7.467814
4	0.047	0.2168	117	14.8041	1079845	39.5	7.080543
5	0.041	0.2025	122	13.8867	1004224	26	4.334233
6	0.043	0.2074	123	14.2336	1027544	24	4.093734
7	0.012	0.1095	120	7.4998	544223.1	43.8	3.956937
8	0.037	0.1924	120	13.1693	955624.4	36.4	5.774265
9	0.052	0.2280	120	15.6121	1132891	29.8	5.604184
10	0.036	0.1897	120	12.9901	942622.1	27.2	4.256127
11	0.018	0.1342	120	9.1854	666534.5	33.8	3.739792
12	0.017	0.1304	120	8.9266	647755.1	32.1	3.451628
13	0.048	0.2191	121	15.0126	1087509	39.8	7.184955
14	0.033	0.1817	121	12.4478	901714.9	40.3	6.032292
15	0.038	0.1949	121	13.3575	967618.3	40.1	6.441048
16	0.02	0.1414	121	9.6906	701984.1	41	4.777704
17	0.012	0.1095	121	7.5063	543754.6	37.4	3.375846
18	0.006	0.0775	121	5.3077	384492.5	36.9	2.355171
19	0.019	0.1378	122	9.4533	683621.4	36.5	4.142062
20	0.013	0.1140	122	7.8195	565471.3	38.3	3.595153
21	0.016	0.1265	122	8.6750	627334	39.2	4.082188
22	0.021	0.1449	122	9.9384	718701.4	38.8	4.629012
23	0.014	0.1183	122	8.1147	586817.3	36.4	3.545785
24	0.009	0.0949	122	6.5062	470500.5	35.1	2.741418
25	0.024	0.1549	123	10.6337	767664.9	28.2	3.593593
26	0.042	0.2049	123	14.0671	1015525	28.4	4.787592
27	0.051	0.2258	123	15.5012	1119054	20.3	3.770989
28	0.05	0.2236	123	15.3485	1108029	21	3.862589
29	0.034	0.1844	123	12.6567	913704	31.2	4.732256
30	0.039	0.1975	123	13.5554	978584.6	45.8	7.439983
average =	0.03	0.1671	120.70	11.4447	24886765	34.58	140.2372

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Table 10: Test Data Results For Module 1C Test 2

Intermountain Power Project

Scrubber Unit 'C'
(West to East)

Date: 9/20/2001
Start : 1440 Stop : 1615

A_s	900.00	ft^2
C_p	0.900	
P_g	1.900	*in. H2O*
P_{bar}	25.500	*in. Hg*
P_s	25.640	*in. Hg*
Ms	28.570	*lb/lb-mole*
Bws	0.134	

	ΔP (in. H2O)	Sqrt ΔP (in. H2O)	Ts °F	Vs ft/sec	Qs std dscf/hr	SO2 ppm	SO2 lbs/hr
1	0.015	0.1225	119	8.3778	608985.1	89.9	9.088129
2	0.017	0.1304	118	8.9112	648874.8	92.6	9.974243
3	0.025	0.1581	117	10.7970	787557.8	63.8	8.340867
4	0.023	0.1517	118	10.3651	754745.2	41.1	5.149324
5	0.019	0.1378	117	9.4126	686577	41.7	4.752623
6	0.009	0.0949	118	6.4838	472125.7	42.6	3.338684
7	0.012	0.1095	118	7.4869	545163.9	53.2	4.814451
8	0.012	0.1095	119	7.4934	544692.9	59.6	5.388973
9	0.011	0.1049	119	7.1743	521503.7	52.3	4.527591
10	0.01	0.1000	120	6.8464	496805.4	52.7	4.346153
11	0.014	0.1183	117	8.0798	589354.3	40.6	3.972012
12	0.015	0.1225	118	8.3706	609511.7	40.3	4.077511
13	0.011	0.1049	119	7.1743	521503.7	42.1	3.644581
14	0.018	0.1342	116	9.1536	668844.8	56.7	6.295301
15	0.022	0.1483	115	10.1109	740078.5	58.5	7.186902
16	0.023	0.1517	117	10.3561	755398.9	54.3	6.809015
17	0.026	0.1612	118	11.0204	802459.5	46.7	6.220826
18	0.027	0.1643	118	11.2303	817745.8	49.1	6.665119
19	0.005	0.0707	121	4.8453	350992.1	46.1	2.686002
20	0.018	0.1342	122	9.2012	665388.2	54.8	6.052904
21	0.019	0.1378	122	9.4533	683621.4	56.7	6.434381
22	0.013	0.1140	123	7.8262	564986.1	47.6	4.464294
23	0.009	0.0949	121	6.5006	470905.3	33.7	2.634338
24	0.008	0.0894	118	6.1130	445124.4	31.3	2.312777
25	0.023	0.1517	121	10.3920	752794.1	39	4.873589
26	0.028	0.1673	123	11.4858	829172.9	45.9	6.3178
27	0.031	0.1761	121	12.0647	873963.2	45	6.528505
28	0.03	0.1732	123	11.8889	858275.5	29.6	4.217222
29	0.032	0.1789	119	12.2366	889479.7	21.3	3.145022
30	0.032	0.1789	117	12.2154	891020	21.5	3.18005
average =	0.02	0.1331	119.07	9.1023	19847651	48.34333	157.4392

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Test 3: Module B Compared to Module C

Because it was reported that Module C and Module F had the most difficult time with SO_2 removal it was decided to compare Module B performance with three pumps in operation with Module E (directly opposed to Module B). This would accomplish two things, a) a verification of the original test data taken 12 hours prior to this test on Module B and b) a verification of gas flow distribution between towers and performance verification for Module E.

Figure 4a: Module 1B Test 3

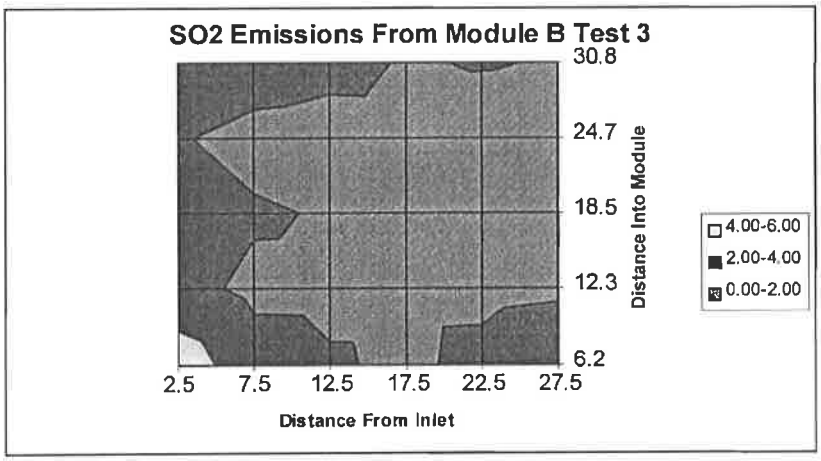

Figure 4b: Module 1E Test 3

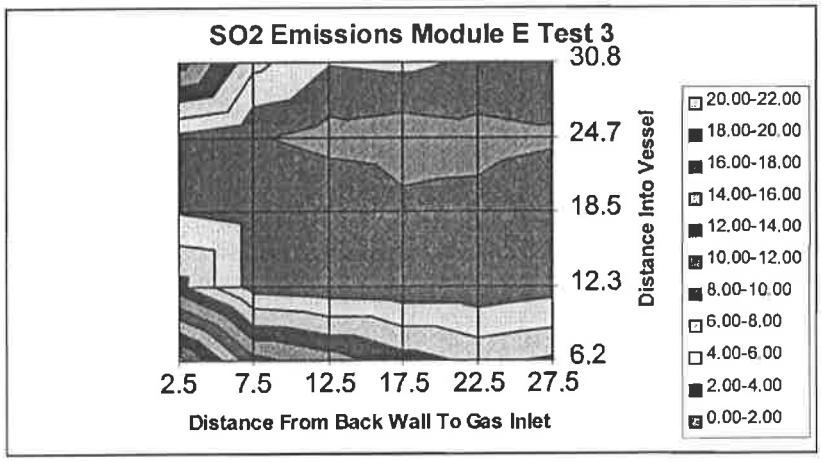

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Table 11: Test Data Results For Module 1B Test 3

Intermountain Power Project

Scrubber Unit 'B'
(West to East)

Date: 9/20/2001
Start : 1945 Stop : 2115

A_s	900.00	ft^2
C_p	0.900	
P_g	1.900	*in. H2O*
P_{bar}	25.500	*in. Hg*
P_s	25.640	*in. Hg*
Ms	28.570	*lb/lb-mole*
Bws	0.134	

	ΔP (in. H2O)	Sqrt ΔP (in. H2O)	Ts °F	Vs ft/sec	Qs std dscf/hr	SO2 ppm	SO2 lbs/hr
1	0.069	0.2627	117	17.9374	1308389	23.5	5.104027
2	0.043	0.2074	117	14.1602	1032872	16.8	2.880475
3	0.058	0.2408	117	16.4455	1199572	11.1	2.210332
4	0.035	0.1871	117	12.7752	931851	10.5	1.624216
5	0.049	0.2214	117	15.1158	1102581	13.7	2.50749
6	0.057	0.2387	117	16.3031	1189186	16.9	3.336143
7	0.022	0.1483	118	10.1373	738155.3	21.7	2.658983
8	0.01	0.1000	118	6.8346	497664.2	19	1.569633
9	0.012	0.1095	118	7.4869	545163.9	16.8	1.520353
10	0.014	0.1183	118	8.0868	588844.3	15.2	1.485772
11	0.013	0.1140	118	7.7926	567424.5	16.3	1.535337
12	0.015	0.1225	118	8.3706	609511.7	16.9	1.709924
13	0.026	0.1612	119	11.0299	801766.2	18.8	2.502152
14	0.024	0.1549	119	10.5972	770312	17.5	2.237756
15	0.021	0.1449	119	9.9128	720560.9	15.4	1.842042
16	0.02	0.1414	119	9.6739	703195.5	14.4	1.680918
17	0.009	0.0949	119	6.4894	471717.9	16	1.252883
18	0.003	0.0548	119	3.7467	272346.4	16.8	0.75952
19	0.019	0.1378	120	9.4371	684799.1	19	2.159856
20	0.013	0.1140	120	7.8061	566445.4	14.3	1.344628
21	0.004	0.0632	120	4.3300	314207.4	14.5	0.756297
22	0.005	0.0707	120	4.8411	351294.5	14.9	0.868892
23	0.002	0.0447	120	3.0618	222178.2	15.2	0.5606
24	0.003	0.0548	120	3.7499	272111.6	15.6	0.70466
25	0.023	0.1517	121	10.3920	752794.1	22.3	2.786693
26	0.035	0.1871	121	12.8194	928637.7	20.1	3.098493
27	0.041	0.2025	121	13.8748	1005088	17.6	2.936466
28	0.049	0.2214	121	15.1681	1098779	9.7	1.769254
29	0.065	0.2550	121	17.4699	1265520	10.4	2.184793
30	0.041	0.2025	121	13.8748	1005088	10.9	1.818607
average =	0.03	0.1509	119.00	10.3240	22518058	16.06	59.40719

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Table 12: Test Data Results For Module 1E Test 3

Intermountain Power Project

Scrubber Unit 'E'
(West to East)

Date: 9/20/2001
Start : 2205 Stop : 2345

A_s	900.00	ft^2	
C_p	0.900		
P_g	1.900	*in. H2O*	
P_{bar}	25.500	*in. Hg*	
P_s	25.640	*in. Hg*	
Ms	28.570	*lb/lb-mole*	
Bws	0.134		

	ΔP (in. H2O)	Sqrt ΔP (in. H2O)	Ts °F	Vs ft/sec	Qs std dscf/hr	SO2 ppm	SO2 lbs/hr
1	0.081	0.2846	120	19.4851	1413933	88.2	20.70168
2	0.065	0.2550	120	17.4549	1266610	59.9	12.59441
3	0.069	0.2627	120	17.9839	1305001	50.2	10.87484
4	0.061	0.2470	120	16.9093	1227019	43.9	8.941778
5	0.051	0.2258	120	15.4613	1121945	40.3	7.505585
6	0.057	0.2387	120	16.3455	1186107	42	8.269536
7	0.013	0.1140	119	7.7993	566934.3	92.8	8.73351
8	0.005	0.0707	119	4.8369	351597.7	52	3.034992
9	0.004	0.0632	119	4.3263	314478.6	49.3	2.57363
10	0.004	0.0632	119	4.3263	314478.6	45.6	2.380477
11	0.005	0.0707	119	4.8369	351597.7	42.2	2.463012
12	0.008	0.0894	119	6.1183	444739.9	41.6	3.071196
13	0.007	0.0837	121	5.7330	415299.4	55.7	3.839941
14	0.006	0.0775	121	5.3077	384492.5	48.7	3.108315
15	0.009	0.0949	121	6.5006	470905.3	51	3.986684
16	0.008	0.0894	121	6.1289	443973.7	35	2.579487
17	0.005	0.0707	121	4.8453	350992.1	46.1	2.686002
18	0.008	0.0894	121	6.1289	443973.7	47.7	3.515473
19	0.011	0.1049	121	7.1867	520605.3	40.8	3.525956
20	0.007	0.0837	121	5.7330	415299.4	32.1	2.212964
21	0.003	0.0548	121	3.7531	271877.3	26.7	1.205014
22	0.002	0.0447	121	3.0644	221986.9	22.6	0.832806
23	0.004	0.0632	121	4.3338	313936.8	24	1.250724
24	0.008	0.0894	121	6.1289	443973.7	22.8	1.680352
25	0.098	0.3130	122	21.4694	1552573	50.2	12.9379
26	0.071	0.2665	122	18.2741	1321503	30.2	6.624957
27	0.059	0.2429	122	16.6584	1204661	20.5	4.099461
28	0.073	0.2702	122	18.5297	1339986	20	4.448754
29	0.044	0.2098	122	14.3858	1040316	21.6	3.730156
30	0.038	0.1949	122	13.3690	966786.7	23	3.691192
average =	0.03	0.1476	120.60	10.1138	21987583	42.22333	157.1008

Conclusions and Recommendations:

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There are several conclusions that can be reached by a careful analysis of the data presented above. The conclusions and recommendations are subject to final desired operation condition of the facility. Namely, two pumps or three pumps per tower, which two pumps in operation, value of lower emissions for a turbine uprate or new unit offsets and many other scenarios.

Conclusions Relative to Performance Guarantees

The conclusions drawn from testing of the demonstration module when compared to the other modules are overwhelming. When the results are summarized, the conclusion relative to performance requirements are as follows.

Table 13: Test 1 Module B&C Comparison – 3 Pump Operation

Module	Average Velocity, Ft/sec	Average SO_2 Concentration, ppm	Average SO_2 Emissions, lbs/H
1-B (Modified)	**10.22**	**14.58**	**52.13**
1-C (Unmodified)	**10.33**	**48.41**	**169.9**

Table 14: Test 2 Module B&C Comparison – 2 Pump Operation on Module B

Module	Average Velocity, Ft/sec	Average SO_2 Concentration, ppm	Average SO_2 Emissions, lbs/H
1-B (Modified)	**11.44**	**34.58**	**140.2**
1-C (Unmodified)	**9.10**	**48.34**	**157.4**

Table 15: Test 3 Module B&E Comparison – 3 Pump Operation

Module	Average Velocity, Ft/sec	Average SO_2 Concentration, ppm	Average SO_2 Emissions, lbs/H
1-B (Modified)	**10.32**	**16.06**	**59.41**
1-E (Unmodified)	**10.11**	**42.22**	**157.1**

Guarantee 1: Greater than 50% Reduction SO_2 Mass Emissions with Both Towers Operating with 3 pumps in Operation

The performance of the modified module B far exceeds this requirement. As seen in Tests 1 and 3, with three pumps in operation, the modified module has an SO_2 emission of 37.8% of module E and 30.6% of module C. Both of these values are well below the guarantee value of 50% reduction, even though the velocity to the modified module was approximately the same in both cases.

Guarantee 2: Similar SO_2 emissions from the Modified Tower with Two Pumps In Operation as the Towers with Three Pumps in Operation

The performance of the modified module B also exceeds this requirement. As seen in Tests 2, with two pumps in operation, the modified module has an SO_2 emission rate of 140.2 lbs/h versus an emission rate from module C of 157.4 lbs/H. This represents a reduction in emissions rates of 11% even though the module was processing 25% more flue gas. When the recycle pump was removed from service, the pressure drop in the modified tower dropped and thus the module was forced to process more flue gas as a result. This further reduced the "effective" L/G by increasing the G to the B vessel by over 10%. Thus, the actually L/G reduction in this case was nearly 40% not 33% as originally assumed. Even under this testing abnormality, the modified tower met and exceeded the required performance.